VIRGINIA NRCS RUSLE2 QUICK GUIDE

Making LS Determinations for Basic RUSLE2 Calculations in Virginia

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SECTION A. INTRODUCTION & APPLICABILITY

1. **Purpose**

   In a basic RUSLE2 calculation, just two numbers are used to represent the field's topography: a slope length (L) in feet and a slope steepness (S) in percent. The specific procedure for measuring L and S in the field is known as an "LS determination." This document explains how to make LS determinations in Virginia.

2. **Procedure has not changed**

   The procedure outlined in this document is essentially the same procedure used for decades by NRCS in Virginia for making LS determinations for use with the "paper-based" Revised Universal Soil Loss Equation (RUSLE1) and the original Universal Soil Loss Equation (USLE).

3. **Applicable only to "basic" RUSLE2 calculations**

   RUSLE2 has certain advanced features compared to USLE and RUSLE1, including the ability to model non-uniform slope shapes and in-field sediment deposition due to flat areas at the bottom of slopes. Currently, Virginia NRCS does not use these advanced features. In order to take advantage of these advanced features, more complex LS data must be entered into RUSLE2 and a LS determination procedure different from the one presented here must be used in the field. As long as RUSLE2 is used only for "basic" calculations, then the LS determination procedure in this document should be used.

4. **Applicable only in Virginia**

   This document is intended solely for NRCS employees and partners in Virginia. The procedures and recommendations in this document may be different from those used by NRCS in other states.

SECTION B. BASIC LS DETERMINATION PROCEDURE

SEE ALSO SECTION C FOR HELPFUL DIAGRAMS ILLUSTRATING MOST OF THE TERMS & CONCEPTS BELOW!

1. **Identify areas of the field to which RUSLE2 applies (and doesn't apply)**

   a. **Hillsides and slopes where overland or "sheet" flow occurs**

      - RUSLE2 APPLIES to "eroding portions" of overland flow areas. These are slopes where sheet & rill erosion occurs (or can occur). They are found in every field. Think of them as "basic RUSLE slopes."
      - RUSLE2 DOES NOT APPLY to "depositional portions" of overland flow areas. These are lower portions of hillsides where slopes flatten out enough for significant sediment deposition to occur. They are not necessarily found in every field.

b. Swales, drainageways, ditches, etc. where concentrated flow occurs

- RUSLE2 NEVER APPLIES to concentrated flow areas. These are areas where gully erosion occurs (or can occur). They are not necessarily found in every field.

2. Pick one slope to represent all areas of field to which RUSLE2 applies

a. Get to know the field

Walk and shoot a wide range of slopes within field (see B.3. below for details on how to shoot slopes)

b. Pick the "average" slope…

Not the steepest, not the flattest, but something in between – the "average" or typical slope. This is consistent with the traditional LS determination approach used by NRCS in Virginia. See also Section C!

c. But plan for the worst!

Recognize that planning to meet a soil conservation goal (e.g., "T") for the average slope will probably leave the field's steeper slopes under-protected. Use judgment and plan proactively to help ensure that all slopes are properly protected (e.g., encourage your client to "go beyond T"). See also Section C!

d. Keep it real

Pick an *actual* slope in the field to be your representative slope and use LS values for that slope to represent the field. This is recommended over creating an "imaginary" slope based on calculated averages for a range of measured LS values.

3. How to shoot a slope (determine LS)

a. Select, then walk, a single overland flow path down the slope.

- START your flow path at point near top of hill where overland flow of runoff begins. Flag this point.
- WALK along the straight-line path that overland flow of water would take as it moves downhill from your starting point – i.e., a path running downhill perpendicular to contour lines that would appear on a topo map. Disregard any micro-topographic obstacles to downhill flow, such as surface roughness, crop rows, vegetation, etc. – i.e., imagine the field has just been clean-tilled with a smooth finish. Do not disregard permanent or semi-permanent landscape features such as terraces, diversions, ditches, embankments, roads, etc.
- END at the point along your overland flow path where either (a) the slope flattens out enough for deposition to begin, or (b) concentrated flow begins. Flag this point.
- Hint: visualize and/or sketch the hillslope profile associated with your overland flow path (i.e., "cut" the hillside vertically along flow path, then view from side). This can help significantly with deposition and slope shape issues. See Figures 4.A. and 4.B. for examples of hillslope profiles.

b. Determine length of slope (L)

- L is the distance in feet from the START point to the END point of your overland flow path – i.e., "slope length is the the distance from the point of origin of overland flow to the point where either deposition or concentrated flow begin"
- Measure slope length by pacing or with a measuring wheel. Do not use a tape. Round to nearest 5 or 10 feet. Note this rule of thumb: RUSLE slope lengths on most landscapes are less than 250 feet and usually do not exceed 400 feet.
- Don't agonize over it. Modest changes in L usually have little impact on final RUSLE2 outcomes.

c. Determine slope steepness (S)

- S is the slope grade in percent (rise/run x 100) of a straight line drawn from START point to END point of your overland flow path.
- Don't eyeball it. RUSLE2 is more sensitive to changes in S than L. Use an instrument (clinometer, rod and level, etc.). Remember to account for height of instrument off ground!

d. Slope shape issues

- Reality: few slopes are simple (i.e., few hillslope profiles in nature are straight lines).
- RUSLE2: all slopes are simple (i.e., basic RUSLE2 models all hillslope profiles as straight lines).
- "Straightening" or simplifying concave or convex slope shapes in order to model them in RUSLE2 tends to further reduce accuracy of soil loss estimates in predictable ways, as shown in Figure 4. Factor this into your judgment when making LS determinations.
- Remember: the RUSLE slope does not end just because the slope "breaks" (i.e., a change in steepness occurs). For example, if the slope gets steeper as you walk downhill, you are on a convex slope. Do not end the RUSLE slope until you reach the point where either deposition or concentrated flow begin. If the slope becomes less steep as you walk downhill, you are on a concave slope. In this case, only end the RUSLE slope if, based on your judgment, the slope flattens out enough for deposition to occur. If it doesn't flatten out enough, keep on walking.
- See Figures 4.A. and 4.B. for illustrations of these terms and concepts.

SECTION C. ANOTHER OPTION – THE "DOMINANT CRITICAL AREA" CONCEPT

The purpose of this section is to make Virginia conservation planners aware of the "dominant critical area" concept used in some other states and to present it as another option for LS determination.

Almost all agricultural fields in Virginia contain a range of slopes, with the steeper slopes more vulnerable to erosion and the less steep slopes less vulnerable. How do we characterize the overall field with a single LS value and select a single management alternative that neither under-treats the more vulnerable slopes, nor over-treats the less vulnerable slopes?

When slope differences within the field are extreme, the best approach is probably to subdivide the field and plan different treatments for different parts of the field (i.e., "split" the field).

But in most cases, the conservation planner must make a judgment call and "lump", selecting a single LS value to represent a range of slopes within the field. We recommend that the planner be more conservative (or protective) rather than less when making this judgment call, so that vulnerable slopes are adequately treated. Previously in this document, we conveyed this idea by recommending that you "Pick the average slope… but plan for the worst".

In many other states, NRCS uses the "dominant critical area" concept to convey a similar idea. The following paragraphs are taken from documents prepared by Dave Lightle, former NRCS Agronomist at the National Soil Survey Center in Lincoln, NE.

> *Fields rarely are comprised of a single soil map unit with uniform topography. Thus, a method is needed to evaluate the field to choose the "dominant critical area" of the field on which to base the erosion calculation and on which to base the development of the conservation treatment.*
>
> *Planners typically observe the field from a prominent location and together with the soil map, mentally divide the field into several landscapes and make an estimate of the size of each or the percentage each comprises of the total field. Fields typically have flat upland areas, sloping areas, and flat bottomland (depositional) areas in the same field.*

It is usually improper to simply select as representative the landscape that is "dominant" by extent (i.e., occupies the most land area), particularly when this landscape is the flattest and least vulnerable to erosion. If one did this, the steeper landscapes in the field would be under-treated. Additionally, basing the determination on a numerical calculation of the weighted average of all the landscapes or slopes in the field is improper since that approach also likely under-treats steeper areas.

Some fields may have a small insignificant area of 10% or less of the field or less than a couple of acres that is much steeper and more erosive. These landscapes are "critical", but usually not dominant and it would be impractical to plan the treatment system for this area and apply it to the whole field. This would significantly over-treat the field and would be impractical to the producer. A good option might be to split out this area and develop it as a wildlife area or recreation area with permanent cover or to apply additional agronomic or supporting practices to adequately treat the critical need.

The "dominant critical area" is nether the average landscape in the field, nor the worst case scenario (unless the worst case scenario is large enough that it is representative of the entire field). Thus, the dominant critical area is usually "steeper or worse than average, but not the steepest or worst."

After making on-site observations, the Conservation Planner exercises judgment and selects the landscape or slope that best represents the dominant critical area for the field. Using the LS value for the dominant critical area to represent the field for erosion calculation and conservation planning purposes is a compromise approach that is both practical and protective.

SECTION D. DIAGRAMS & ILLUSTRATIONS

Figures 1.A. and 1.B.: Two types of basic RUSLE slopes

All basic RUSLE slopes you will encounter in the field will fit one of the two simplified models shown below.

Figure 1.A. shows a hillside where the slope flattens out enough near the bottom to cause deposition of sediment eroded from above. In this case, the RUSLE slope ends at the point where deposition begins. Note that a concentrated flow area such as the one shown in Figure 1.A. will not necessarily occur downhill from all depositional areas.

Figure 1.B. shows a hillside where the slope flattens out just a bit near the bottom, but not enough to cause deposition of sediment eroded from above. In this case, the RUSLE slope ends at the point where concentrated flow begins.

Source: adapated from Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE), Agriculture Handbook 703, 1997, page 18. Referred to hereafter in this document as Ag Handbook 703.

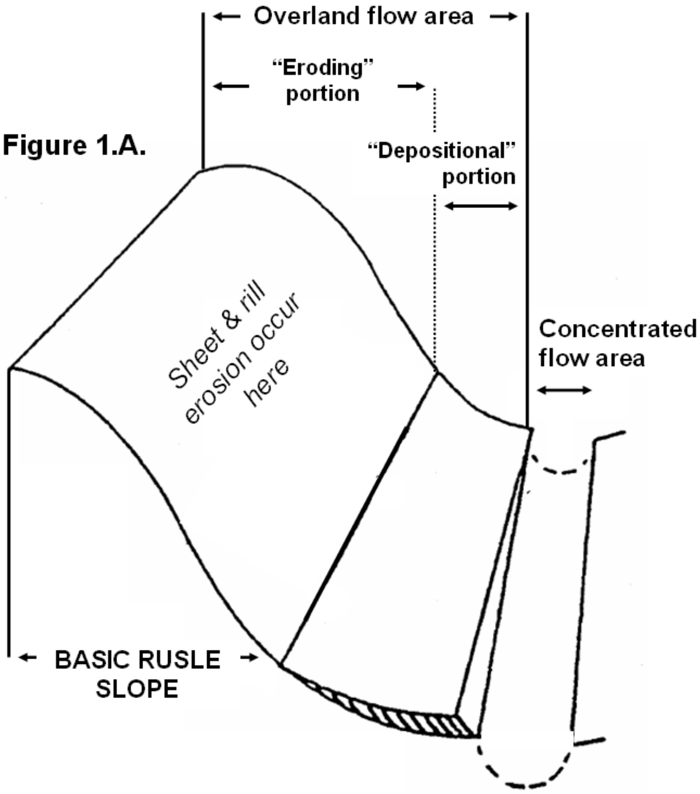


Figure 1.A.

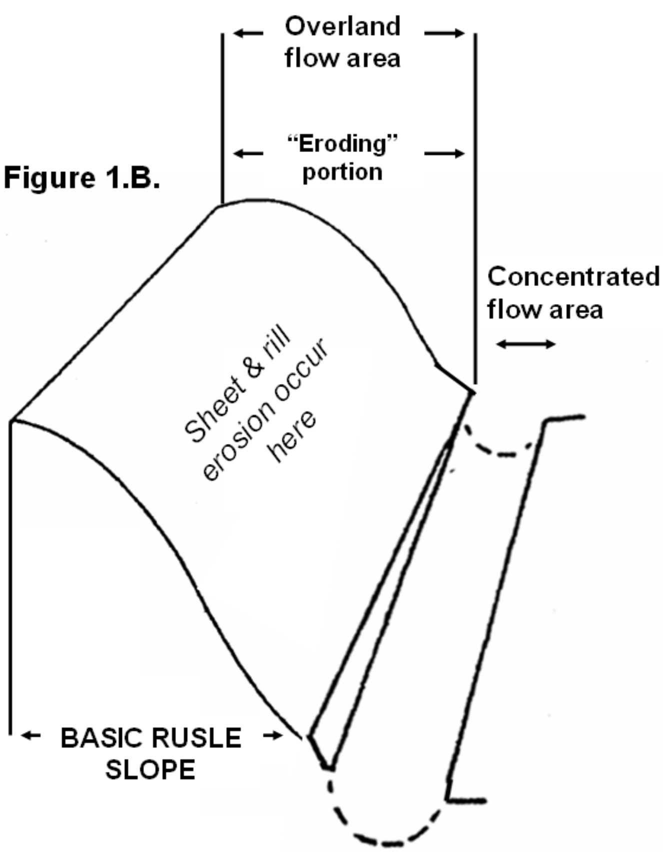
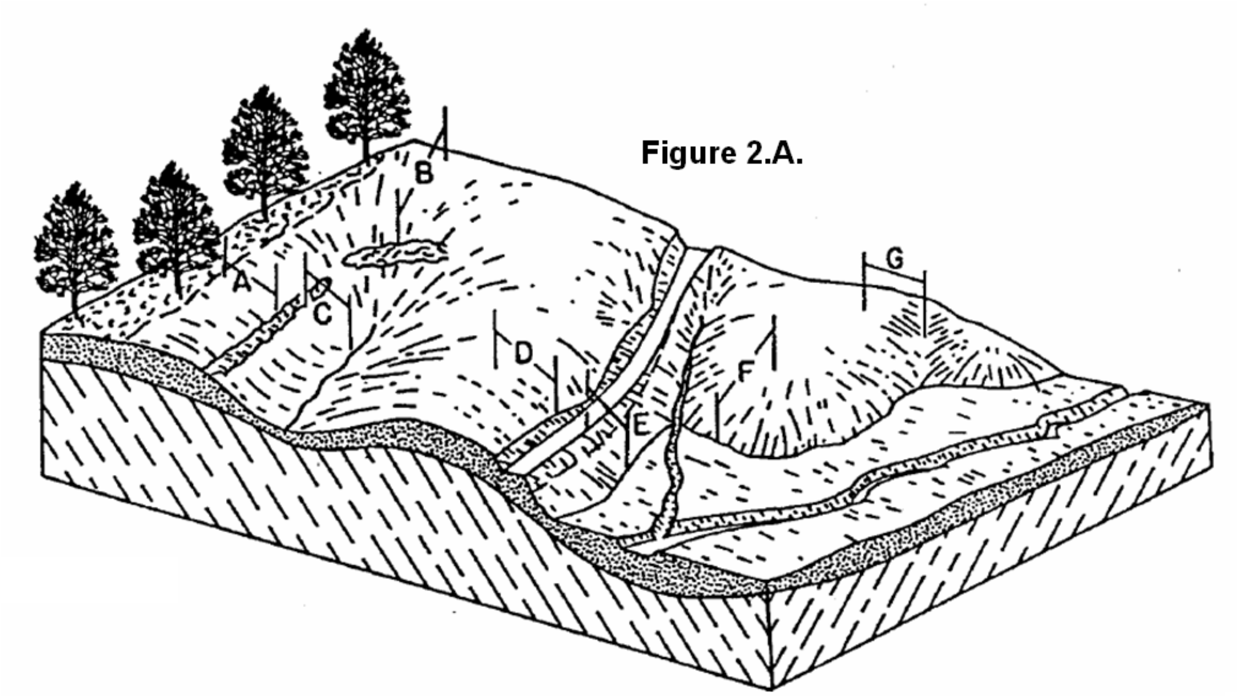


Figure 1.B.

Figures 2.A. and 2.B.: Applying RUSLE2 & shooting slopes on a complex landscape

Figure 2.A. shows a diagram and caption taken directly from Ag Handbook 703, page 131. This diagram is worthy of *very careful study*. In order to make an LS determination for this variable landscape, shooting the seven different slopes shown would not be overkill. One of these slopes must be selected as “representative” of all areas in the field to which RUSLE2 applies.

Figure 2.B. is a modified version of Figure 2.A. showing how to visualize the landscape as being divided into broad areas where RUSLE2 does and does not apply. This helps to illustrate the limitations of using one basic RUSLE2 calculation to predict erosion for the entire area inside the marked field boundary: (1) all areas in white must be modeled using a *single* LS value, while (2) erosion or deposition occuring in the black and cross-hatched areas *can’t* be modeled at all!



Typical slope lengths (Dissmeyer and Foster 1980). Slope A— If undisturbed forest soil above does not yield surface runoff, the top of slope starts with edge of undisturbed forest soil and extends down slope to windrow if runoff is concentrated by windrow. Slope B—Point of origin of runoff to windrow if runoff is concentrated by windrow. Slope C—From windrow to flow concentration point. Slope D—Point of origin of runoff to road that concentrates runoff. Slope E—From road to flood plain where deposition would occur. Slope F—On nose of hill, from point to origin of runoff to flood plain where deposition would occur. Slope G—Point of origin of runoff to slight depression where runoff would concentrate.

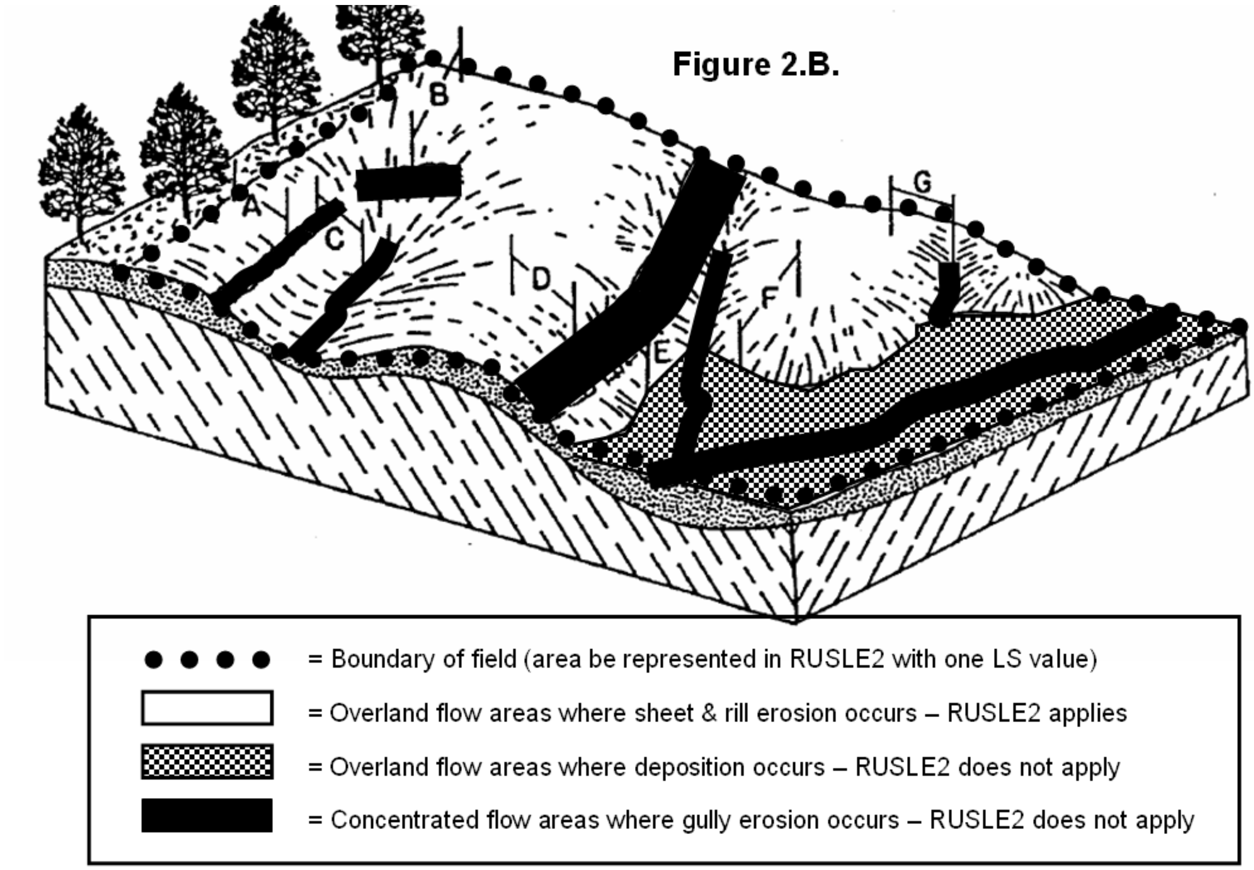

A
B
C
D
E
F
G
= Boundary of field (area be represented in RUSLE2 with one LS value)
= Overland flow areas where sheet & rill erosion occurs – RUSLE2 applies
= Overland flow areas where deposition occurs – RUSLE2 does not apply
= Concentrated flow areas where gully erosion occurs – RUSLE2 does not apply

Figure 2.B.

Figures 3.A. and 3.B.: LS determination example featuring topographic map

These figures are taken directly from Ag Handbook 703, pages 135 and 136.

Figure 3.A. shows aerial photo of a row crop field after a series of erosion events during early stages of crop growth.

Figure 3.B. shows the same field on a topographic map with a 1-foot contour interval. Four numbered overland flow paths are drawn to represent four RUSLE2 slopes. Note how the overland flow paths end at what appear to be concentrated flow areas, which are barely suggested by subtle contour line patterns. This illustrates why it is recommended that topo maps (even very detailed ones) should *not* be used as a substitute for walking the field when making LS determinations.

The table below Figure 3.B. shows LS values for each of the four numbered overland flow paths. If you had to pick one of these overland flow paths to represent the whole field, which one would you select? Answering this question should help you see how selecting an "average" or typical slope, even on a relatively uniform field like this, often demands considerable judgment.

Figure 3.A.

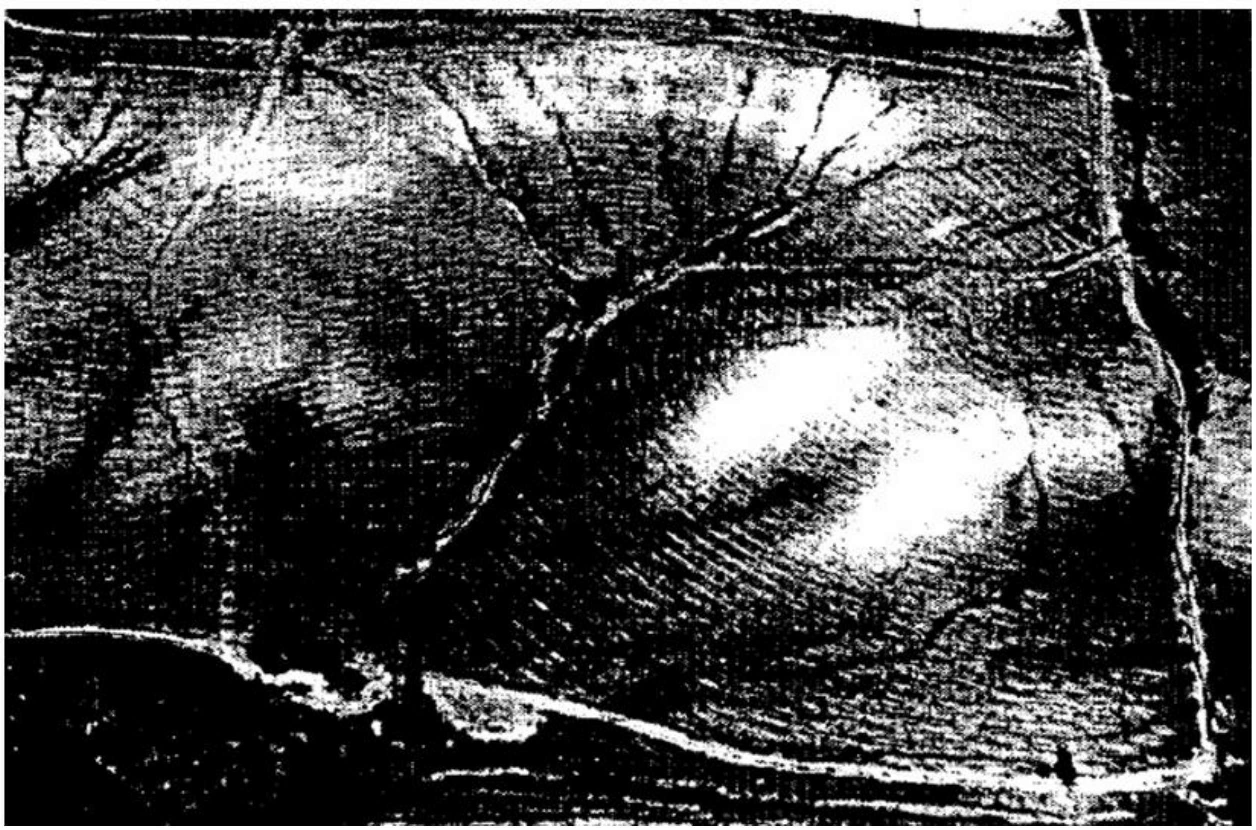


Figure 3.B.

Overland flow path	Slope length (L)	Slope steepness (S)
1	280 ft	12 %
2	325 ft	13 %
3	240 ft	11 %
4	205 ft	13 %

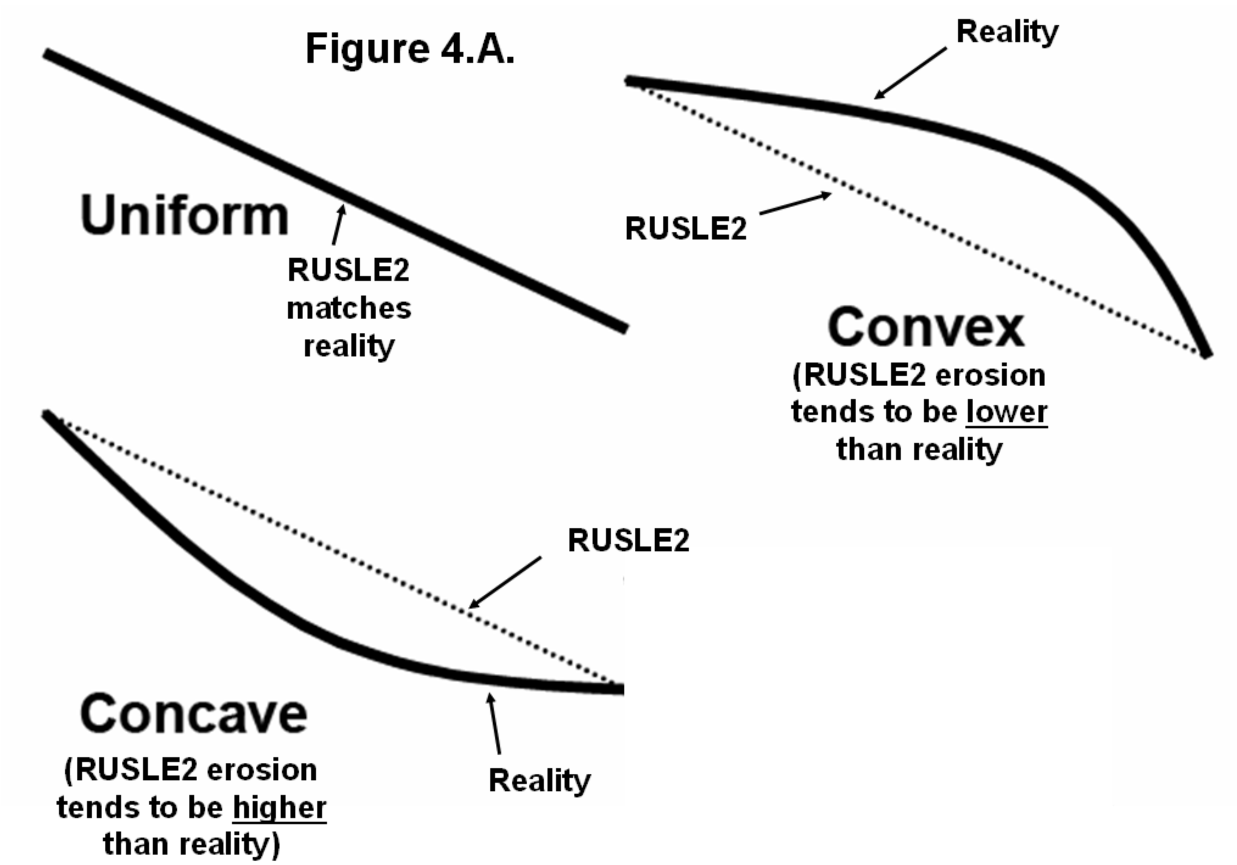
Figure 4.A and 4.B: Examples of hillside profiles and slope shapes

These figures taken from the Draft RUSLE2 User's Guide, January 2003, page 40, illustrate both the concept of a "hillside profile" and various slope shapes.

Figure 4.A. shows three "simple" slope shapes, which include both uniform (straight line) and non-uniform (concave and convex) slopes. Note how "straightening" concave and convex slopes in order to model them with a basic RUSLE2 calculation tends to lead to over- and underestimation of soil loss.

Figure 4.B. shows two "complex" slope shapes. The take-home point here is that a basic RUSLE slope or hillslope profile does not necessarily end just because steepness increases or decreases or does both at various points along the hillslope profile. The RUSLE slope ends only if (a) the slope grade decreases dramatically enough in relation to uphill slope steepness for deposition to occur, or (b) concentrated flow in swales or drainageways begins.

These diagrams are intended solely to illustrate different slope shapes, not to show how to decide if steepness decreases enough for deposition to occur. Assume that the concave profiles or portions of profiles shown below do not decrease enough in steepness to cause "slope-ending" deposition.



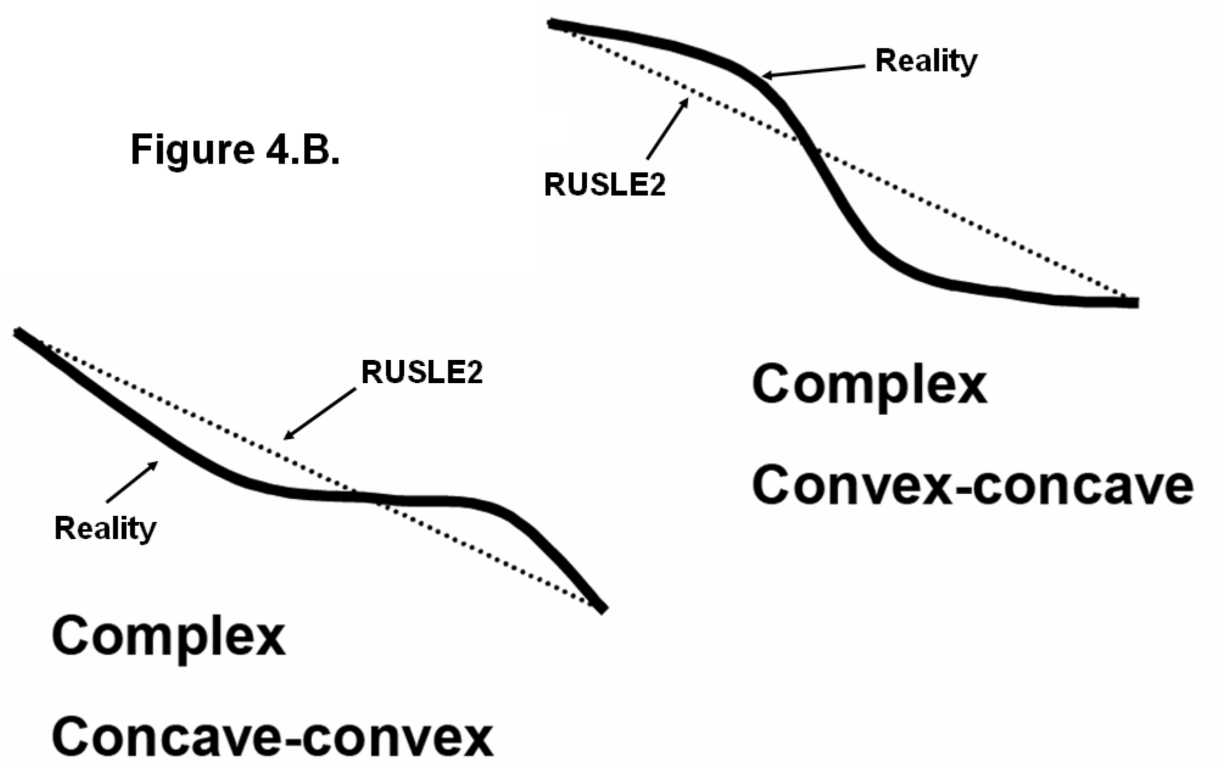


Figure 4.B.
Reality
RUSLE2
Complex
Convex-concave
RUSLE2
Reality
Complex
Concave-convex

SECTION E. TOP 10 LIST OF PRACTICAL LS DETERMINATION TIPS

1. **Do your homework**
   a. Pull maps (topo and soil) and use them. They'll get you in the ballpark on LS before you even set foot in the field. But they are *not* a substitute for walking the field!
   b. Don't forget to pack the necessary tools, including a shovel or stake to help with "height of instrument" adjustments if you will be out there alone.

2. **Define field boundaries early on**

   Before you start walking and shooting slopes, define and sketch boundaries of field or area to be represented by a single LS value (you can always change them later if the area needs to be subdivided).

3. **Walk the field**
   a. The "greener" you are, the more you should walk
   b. The larger the field, the more you should walk
   c. The more complex the topography, the more you should walk

4. **Don't agonize over any one slope**

   Your time is much better spent shooting multiple slopes than debating a single slope to death.

5. **Use your eyes AND your imagination**

   Your job is to divide the field's topography into areas where sheet & rill erosion, deposition, and gully erosion occur, or could potentially occur. Usually you will see little or no evidence of these processes in the field, but that doesn't matter. Visualize the field clean-tilled with a smooth finish, then imagine what types of flow and erosion would occur during violent rain events.

6. **Focus on macro-topography, not micro-topography.**

   Base your key decisions about flow areas, slope starting and ending points, overland flow paths, etc. on the field's macro-topographic features – permanent or semi-permanent features like natural slopes and drainageways, manmade terraces and ditches, etc. Ignore micro-topographic features like surface roughness, tillage ridges, row orientation, etc. that can change from year to year – visualize the field clean-tilled with these micro-topographic features smoothed out.

7. **A short pencil is better than a long memory**

   Take the time to make sketches and record measurements.

8. **Don't hesitate to subdivide**

   If different parts of the field differ significantly in topography, you'll probably save time and do a better job by dividing the field up into two or more management units and assigning separate LS values to each.

9. **Get out of the office!**

   In many cases, LS values for a particular field can either be found in the case file or can be pretty well predicted by an experienced employee sitting next to you in the office. But for so many reasons, you should still walk the field. In particular, you need to account for forms of erosion ignored by RUSLE2 as well as for the many potential sources of error that can make a RUSLE2 result deviate significantly from reality.

10. **Be a planner, not a robot**

    Ultimately, shooting slopes and running RUSLE2 could be done by a robot. But properly evaluating erosion risk and helping a farmer devise and adopt a plan for reducing it requires far more – it requires conservation planning. Planning involves, among other things, continually exercising a mix of field observation skills, independent judgment, technical knowledge, common sense, listening skills, salesmanship, and so much more. When you go to the field to make your LS determination, don't be a robot – be a planner!